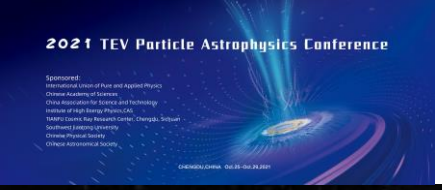


RECENT GAMMA-RAY RESULTS FROM DAMPE

Speaker: Duan Kai-Kai
Shen Zhao-Qiang, Xu Zun-Lei,
Jiang Wei, Li Xiang
(the DAMPE collaboration)

Outline

- Introduction
- Gamma Ray Bright Sources
- Fermi Bubbles with DAMPE
- Gamma Ray Line Search
- Summary

Dark Matter Particle Explorer (DAMPE)

DAMPE ("Wukong") lanuched on Dec. 17, 2015

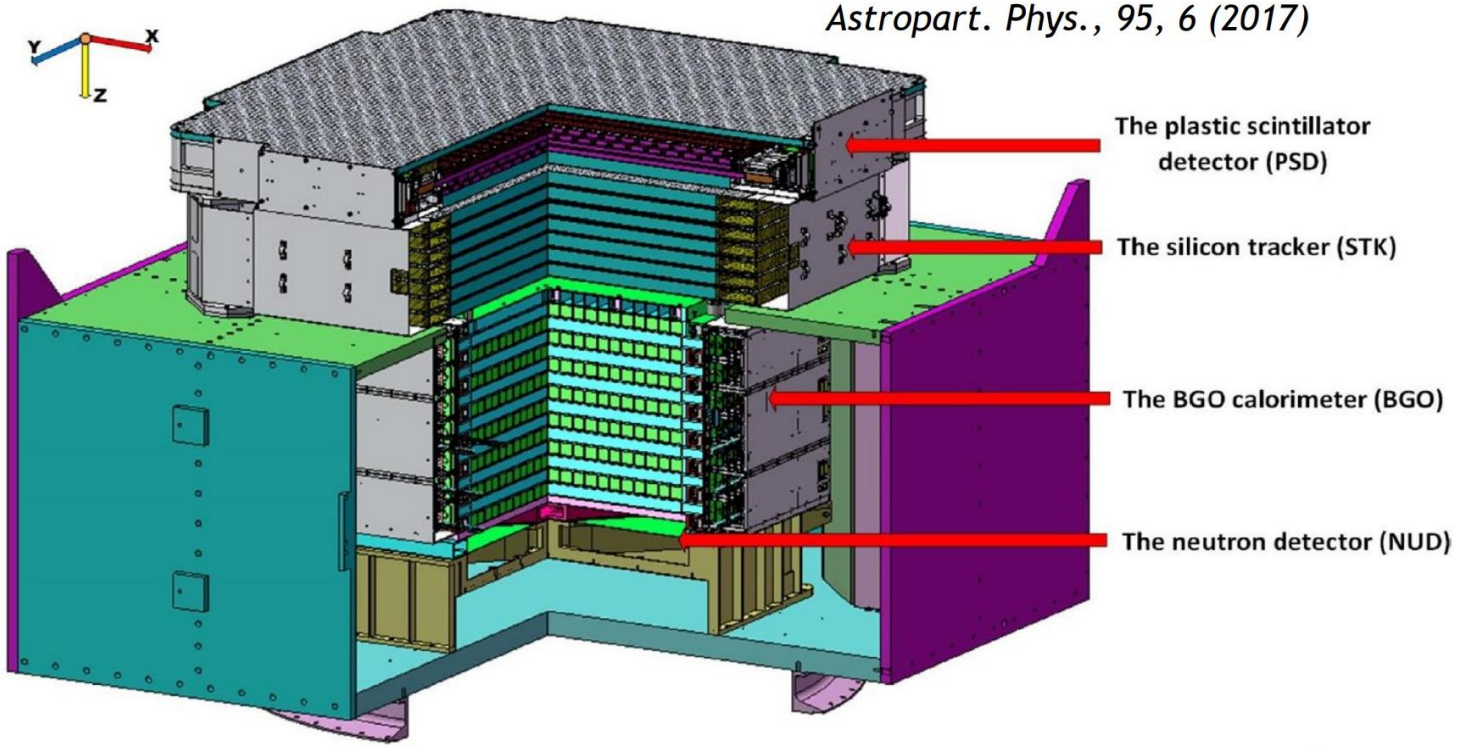
Three major scientific goals

Cosmic ray physics ⇐

⇒ γ-ray astronomy

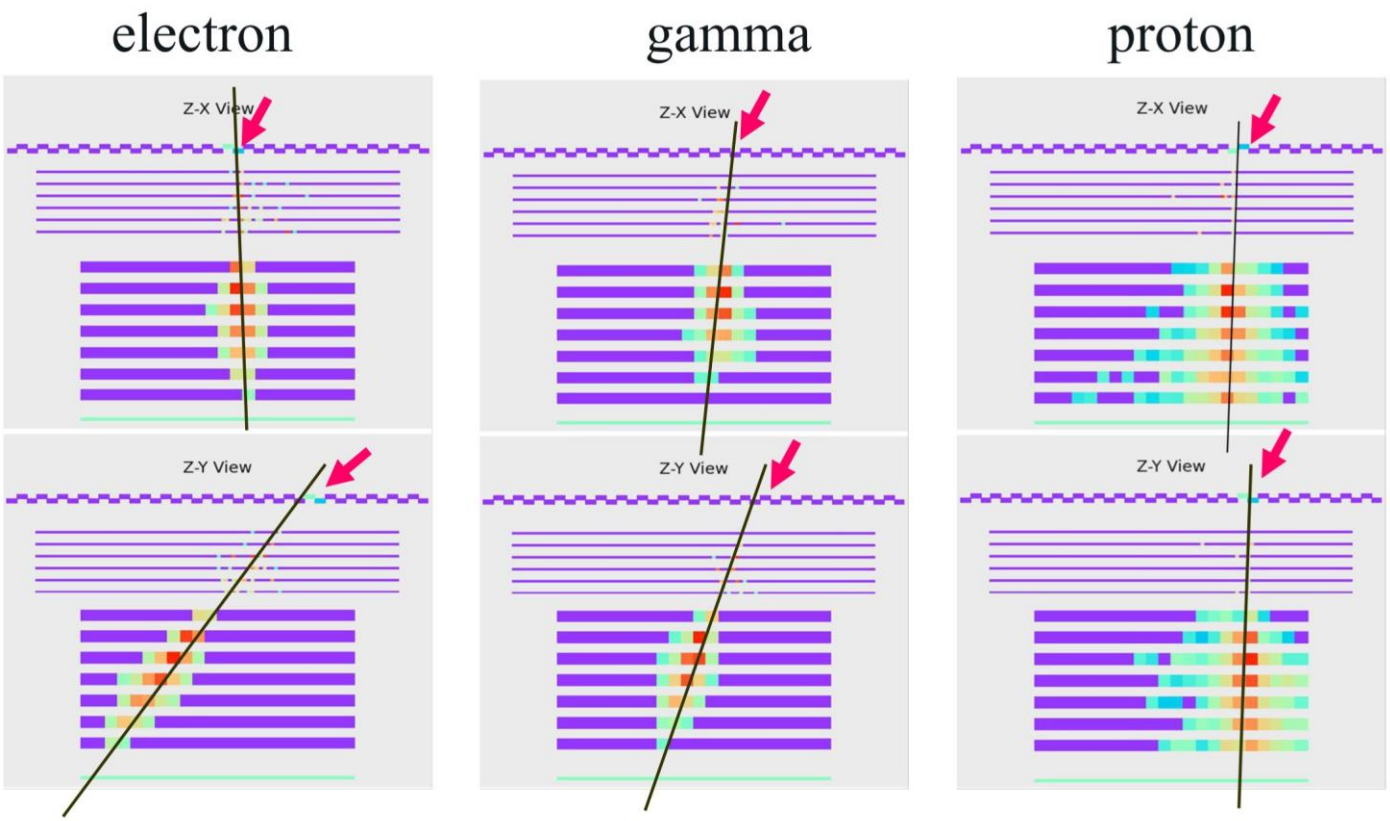
⇓ Dark matter indirect detection

DAMPE Instrument

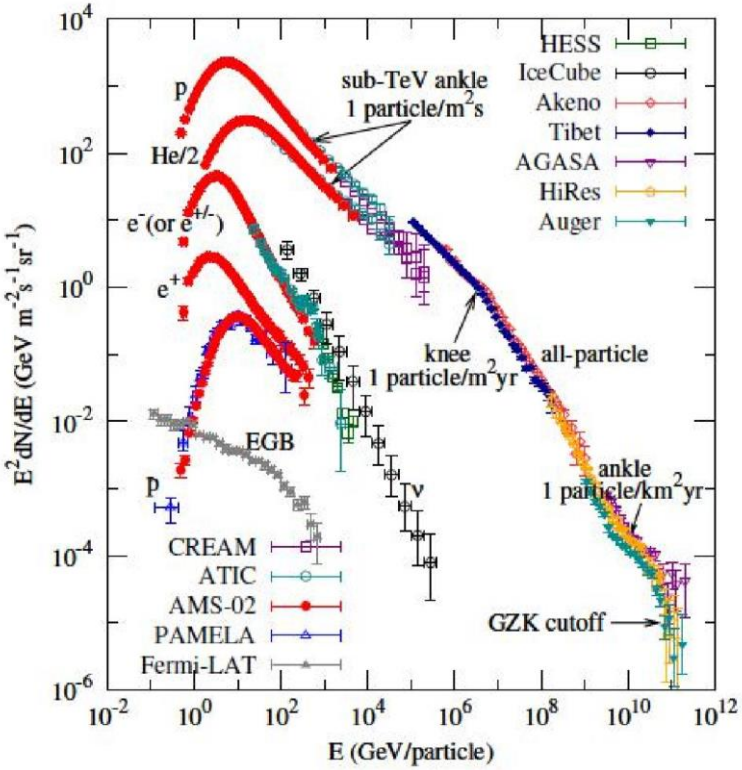


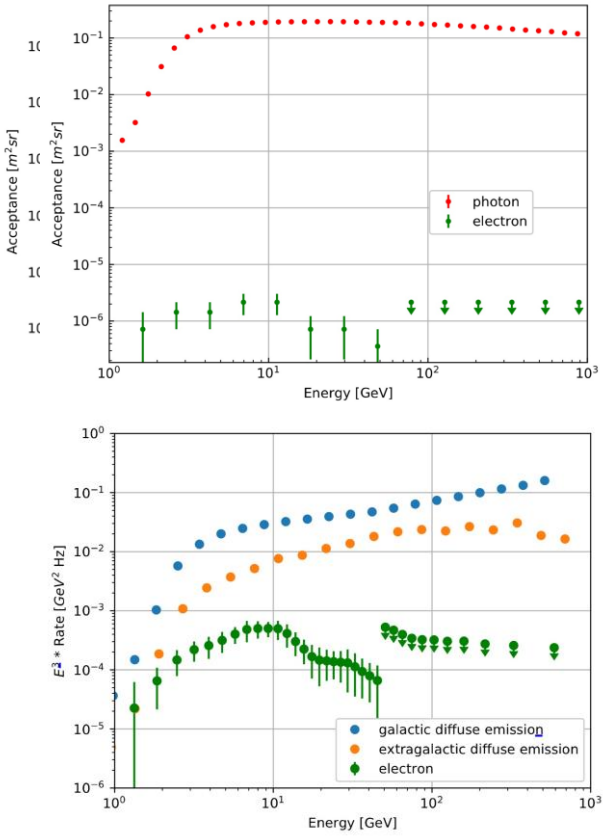
- PSD: charge measuresument via dE/dx and ACD for photons
- STK: track, charge, and photon converter
- BGO: energy measurement, particle (e-p) identification
- NUD: Particle identification

Particle Identification



Low Background γ Samples





Xu et al., RAA, 2018

Performance for γ-ray Observations

Effective area:

~ 1200 cm^2 @ 100 GeV

Angular resolution:

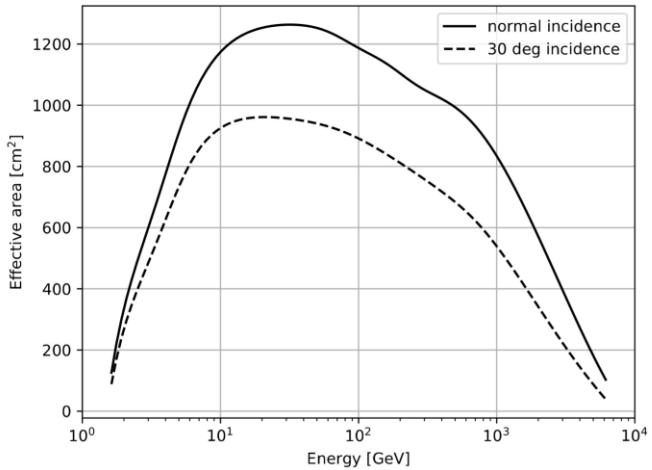
~ 0.3 degree @ 10 GeV

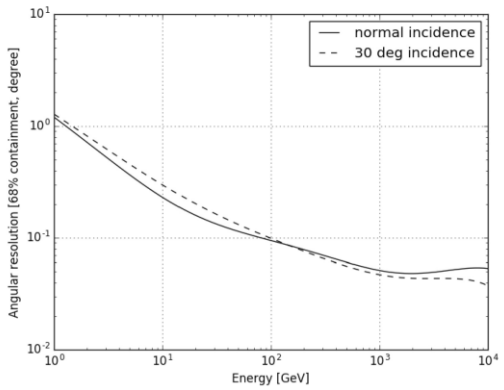
~ 0.1 degree @ 100 GeV

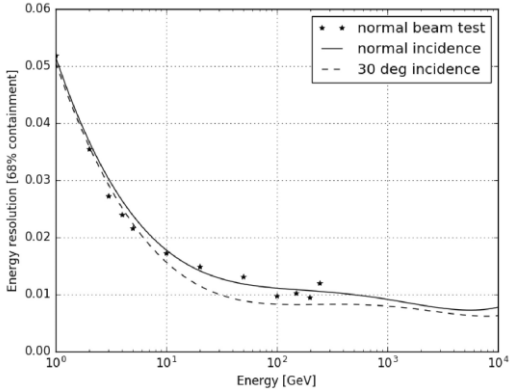
Energy resolution:

~ 2% @ 10 GeV

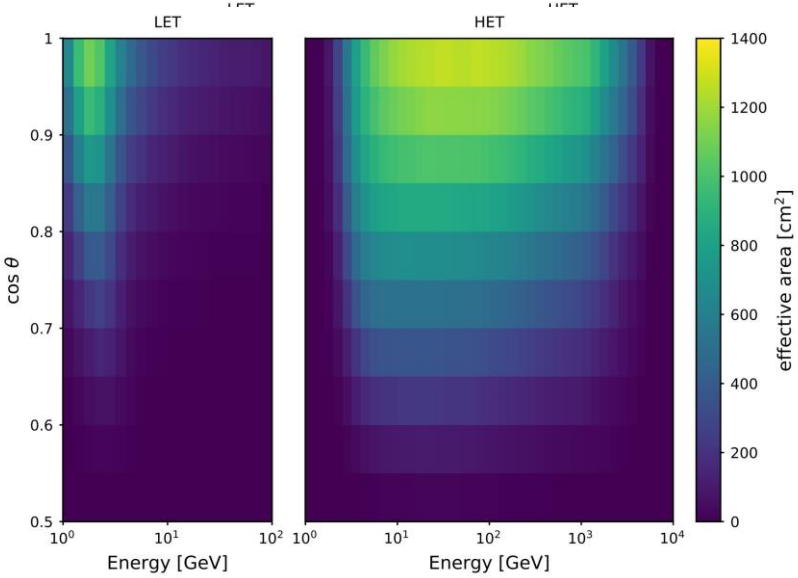
~ 1% @ 100 GeV



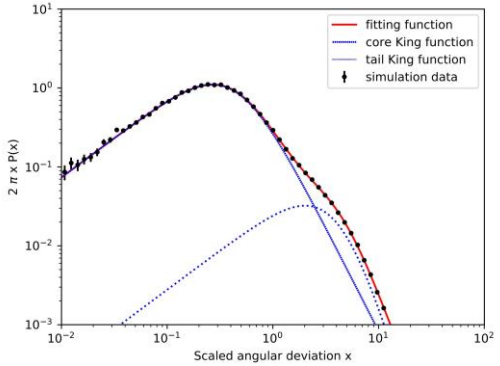




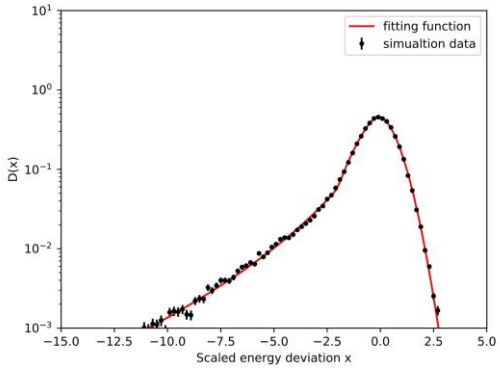
Instrument Response Functions



Effective area



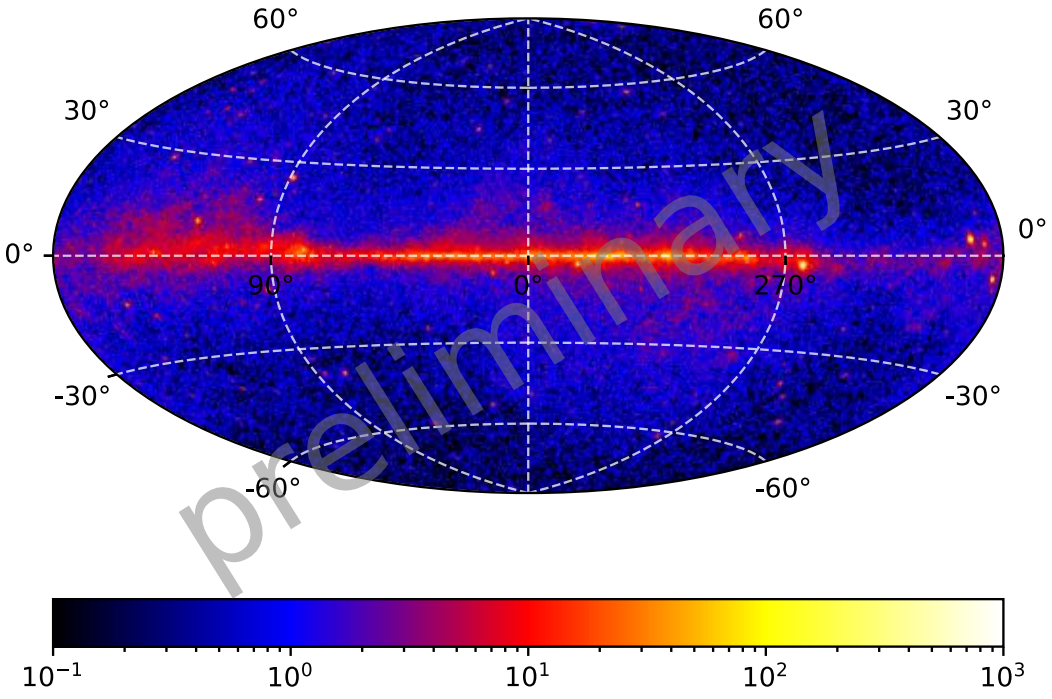
Point-spread Function

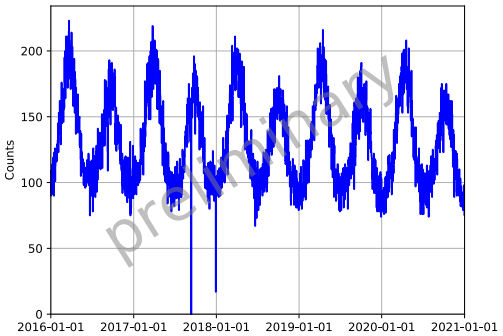


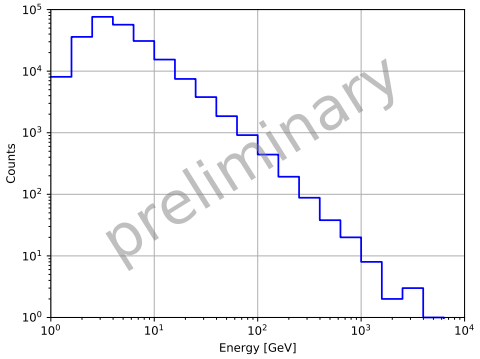
Energy Dispersion

Duan et al., 2019, RAA

First 5-yr counts map

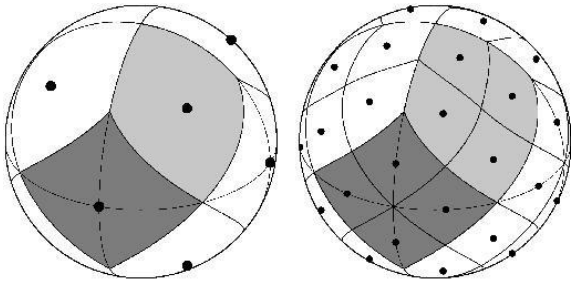


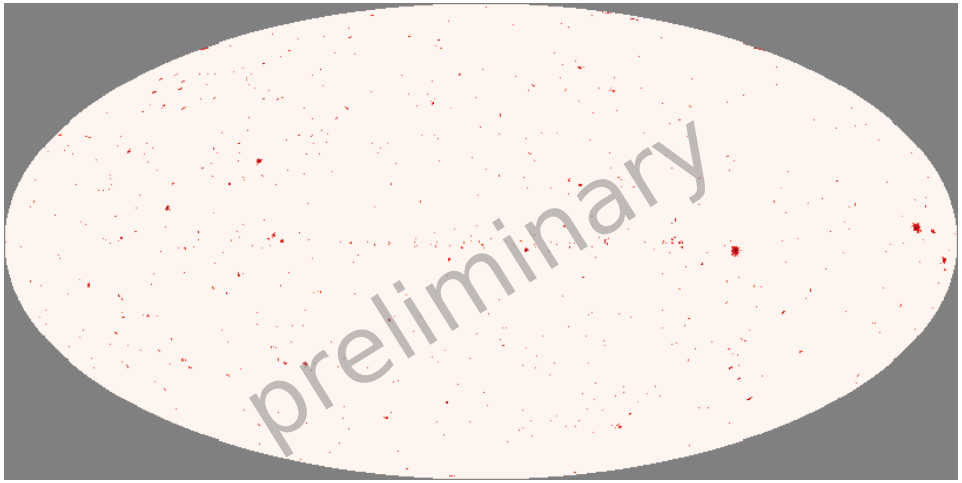


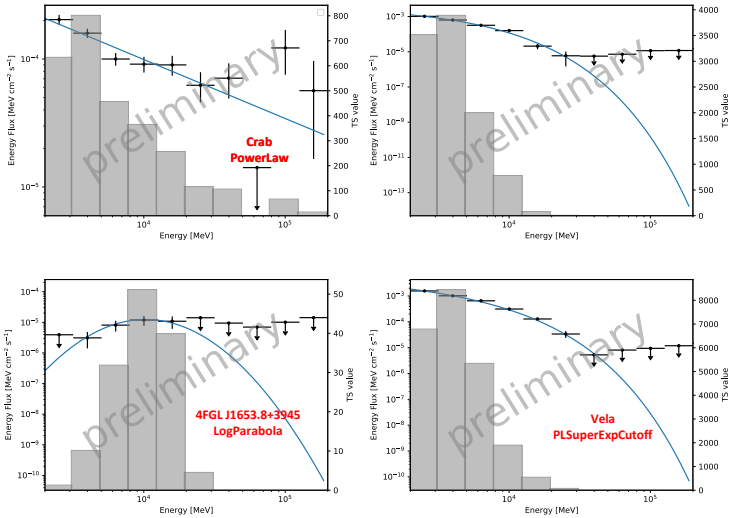


120 M seconds livetime and more than **220, 000** photons above 2 GeV

Blind Search for gamma-ray sources

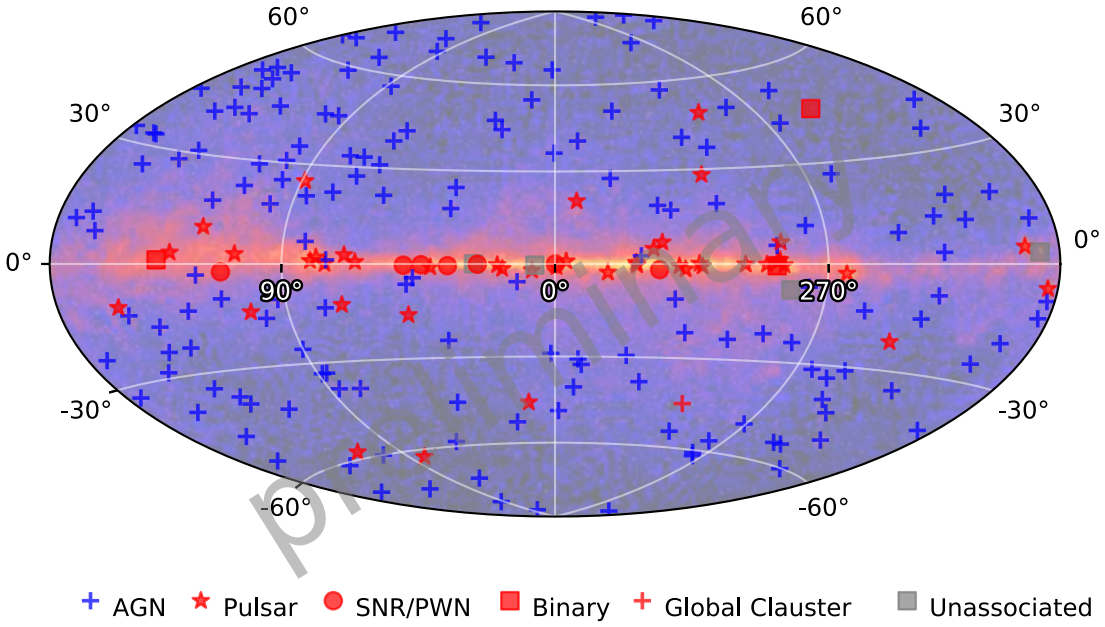






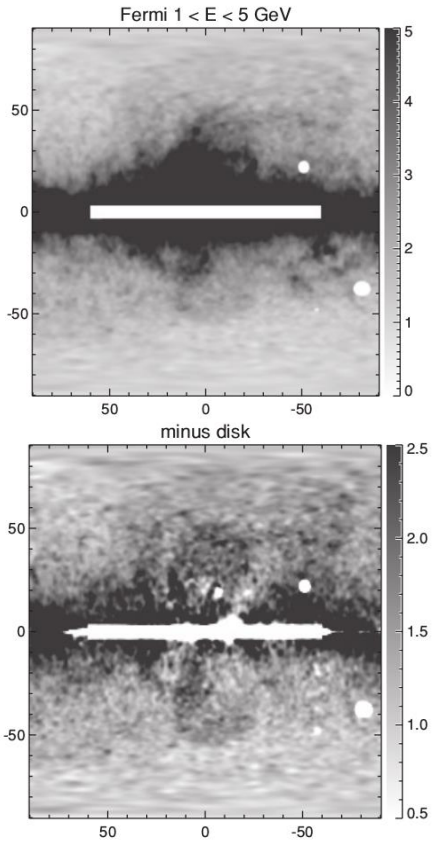
We fit the sources with PowerLaw, LogParabola, PLSuperExpCutoff spectra, find one source favors LogParabola and two sources favor PLSuperExpCutoff spectra.

Bright Sources List

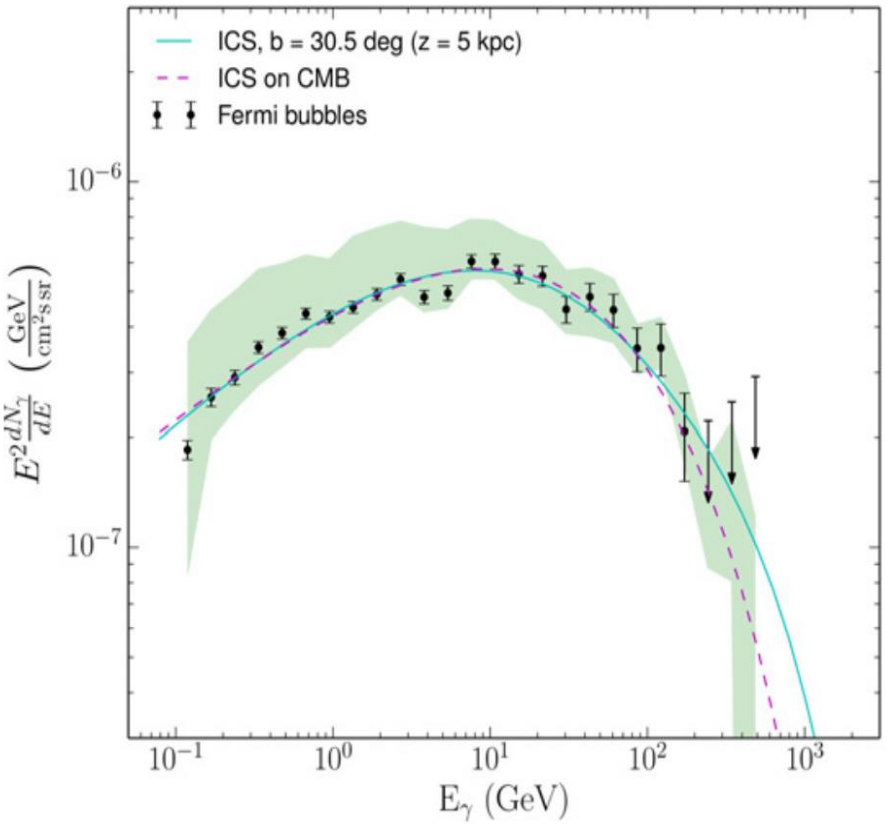


AGN	Pulsar	SNR and/or PWN	Binary	Globular Cluster	Unassociated	Total
163	44	7	3	1	4	222

Bubbles discovered by Fermi -LAT

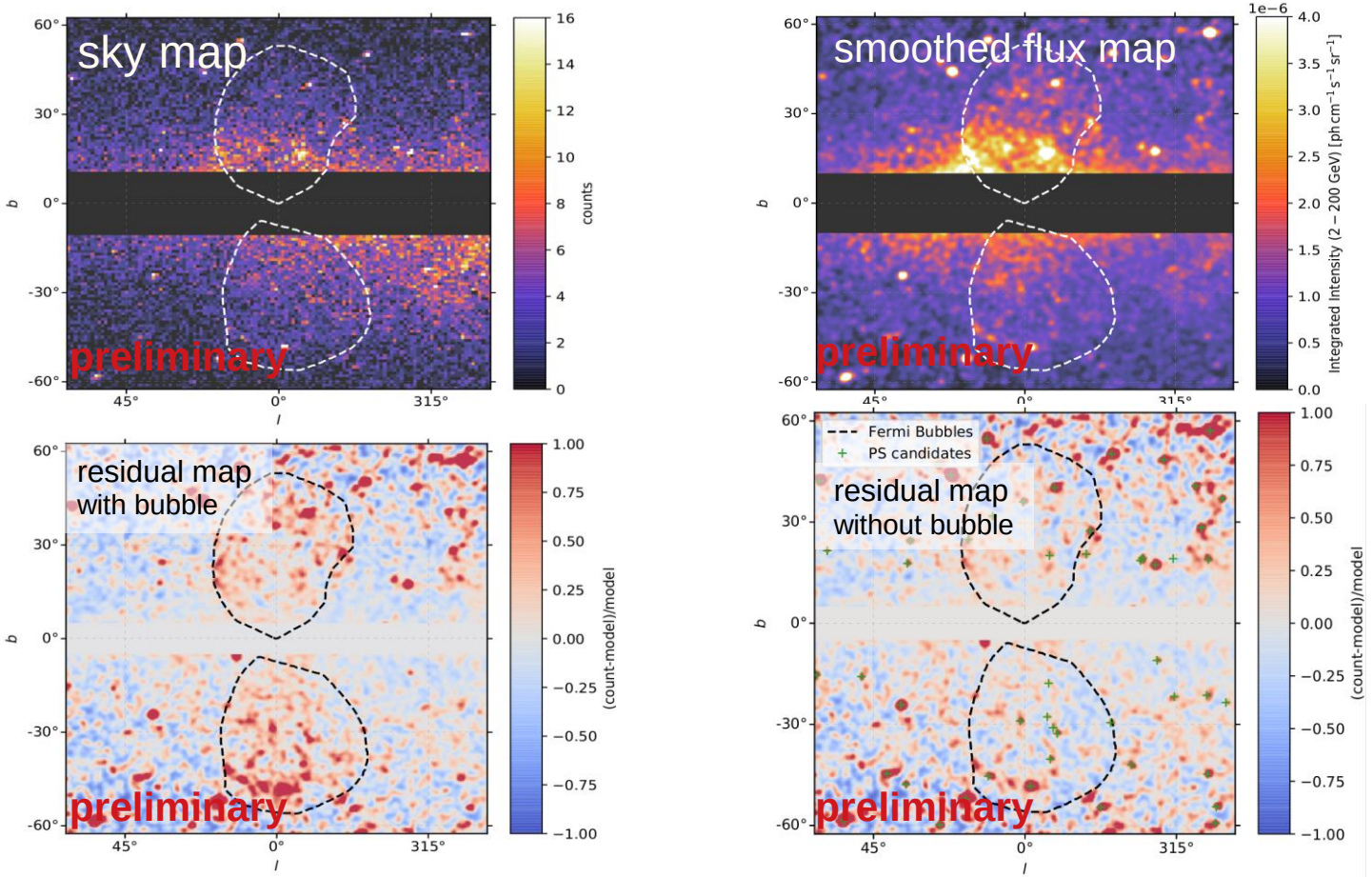


Su+2010

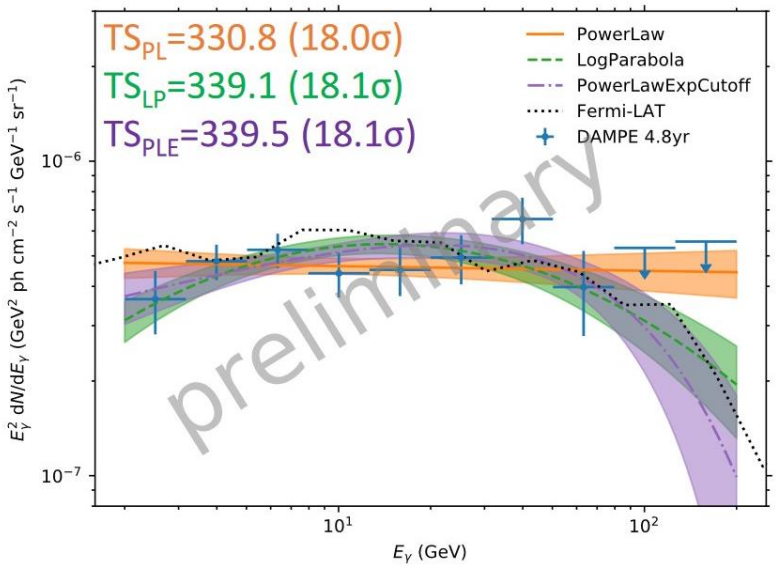


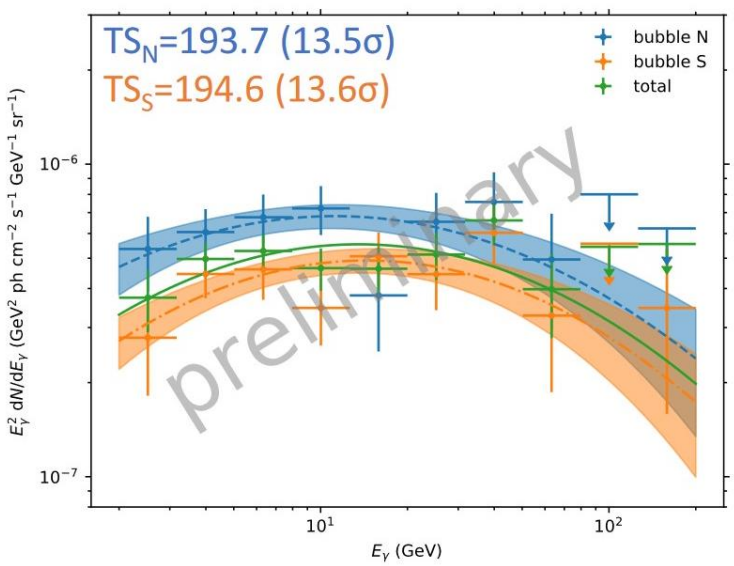
Ackermann+2014

Fermi Bubbles observed by DAMPE



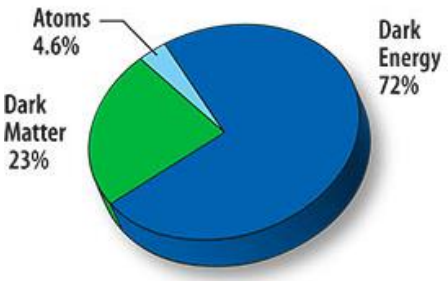
Spectrum of Fermi Bubble





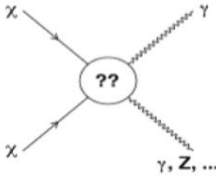
- The Fermi bubbles are significantly detected in DAMPE data (>18σ)
- The best-fit spectral index of PowerLaw model is -2.01 ± 0.05
- The spectrum is found to be slightly curved (2.9σ). The index and cutoff energy are -1.7 ± 0.2 and 78 ± 40 GeV for the PowerLawExpCutoff spectrum
- The two lobes have the similar spectral shape. The north one appears to be stronger, which is probably caused by the uncertainty of Galactic diffuse emission

Gamma-ray Line for Dark Matter Detection

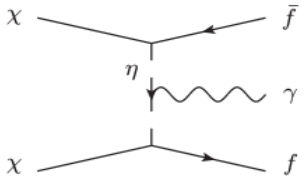


Spectral line

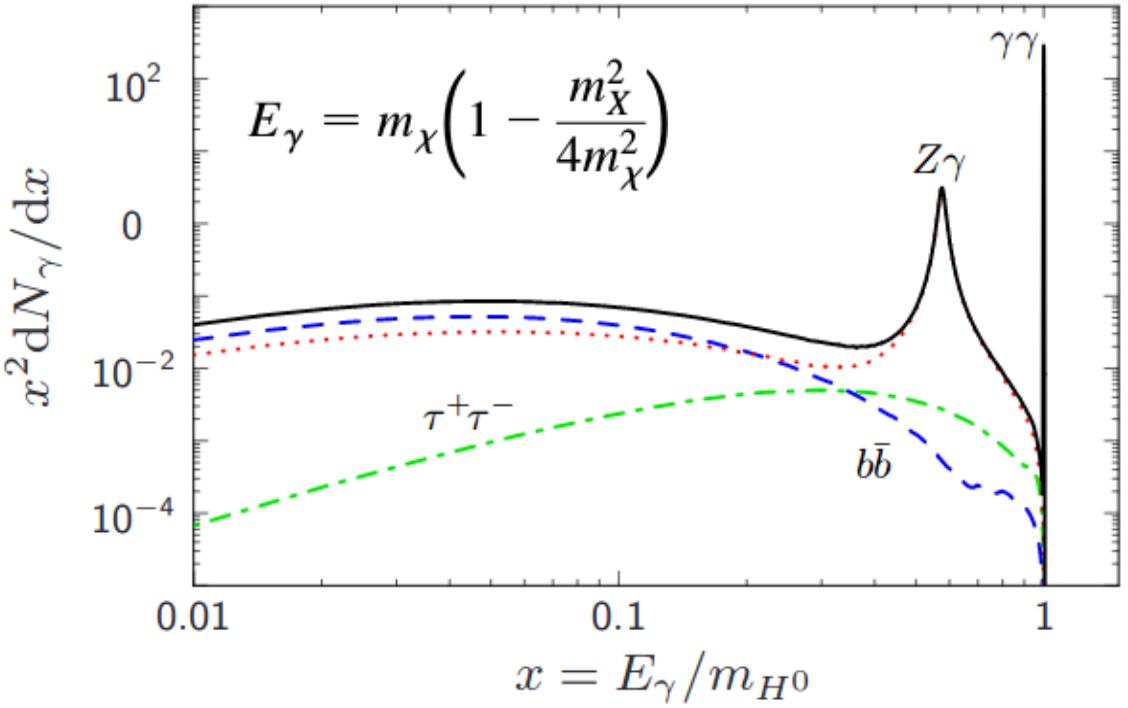
Prompt annihilation into γγ, γZ, γH⁰...
(also prompt decay into photons)



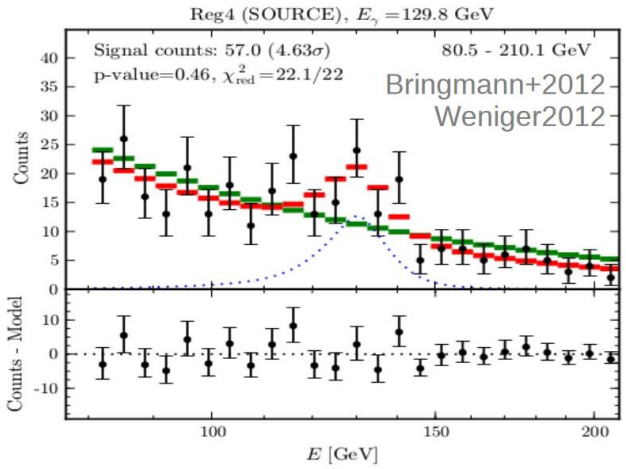
Annihilation or decay

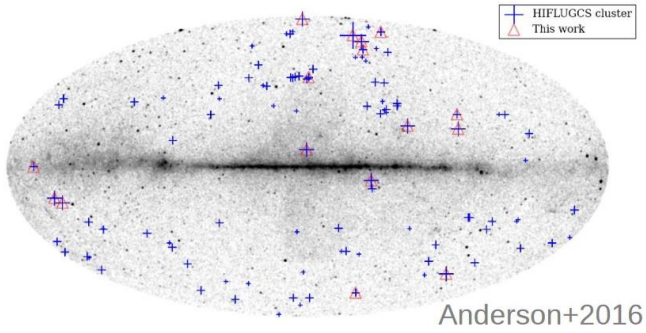


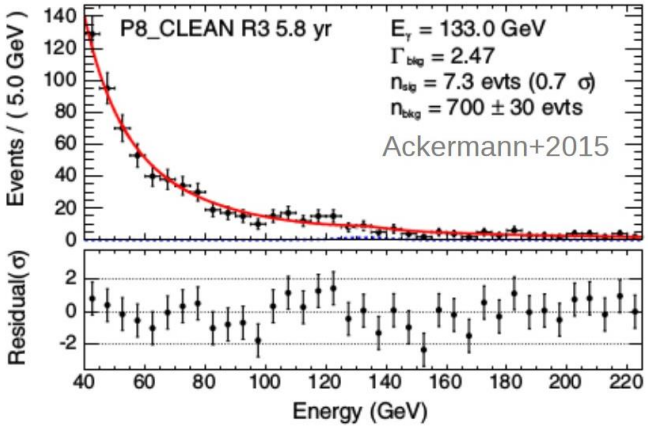
Internal bremsstrahlung
(Bringmann+2012)

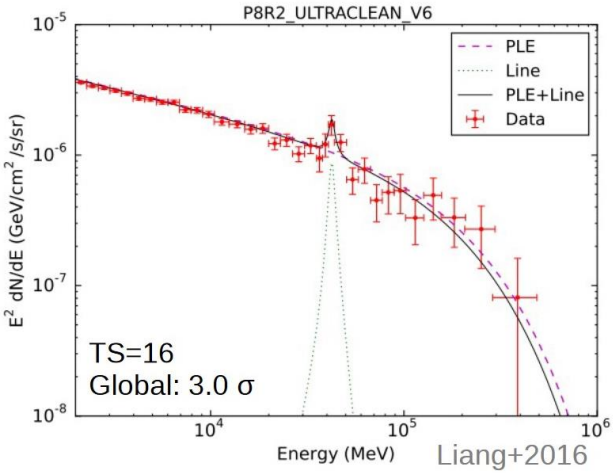


Line Search in Fermi era

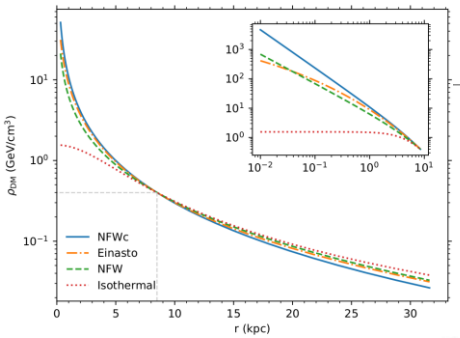


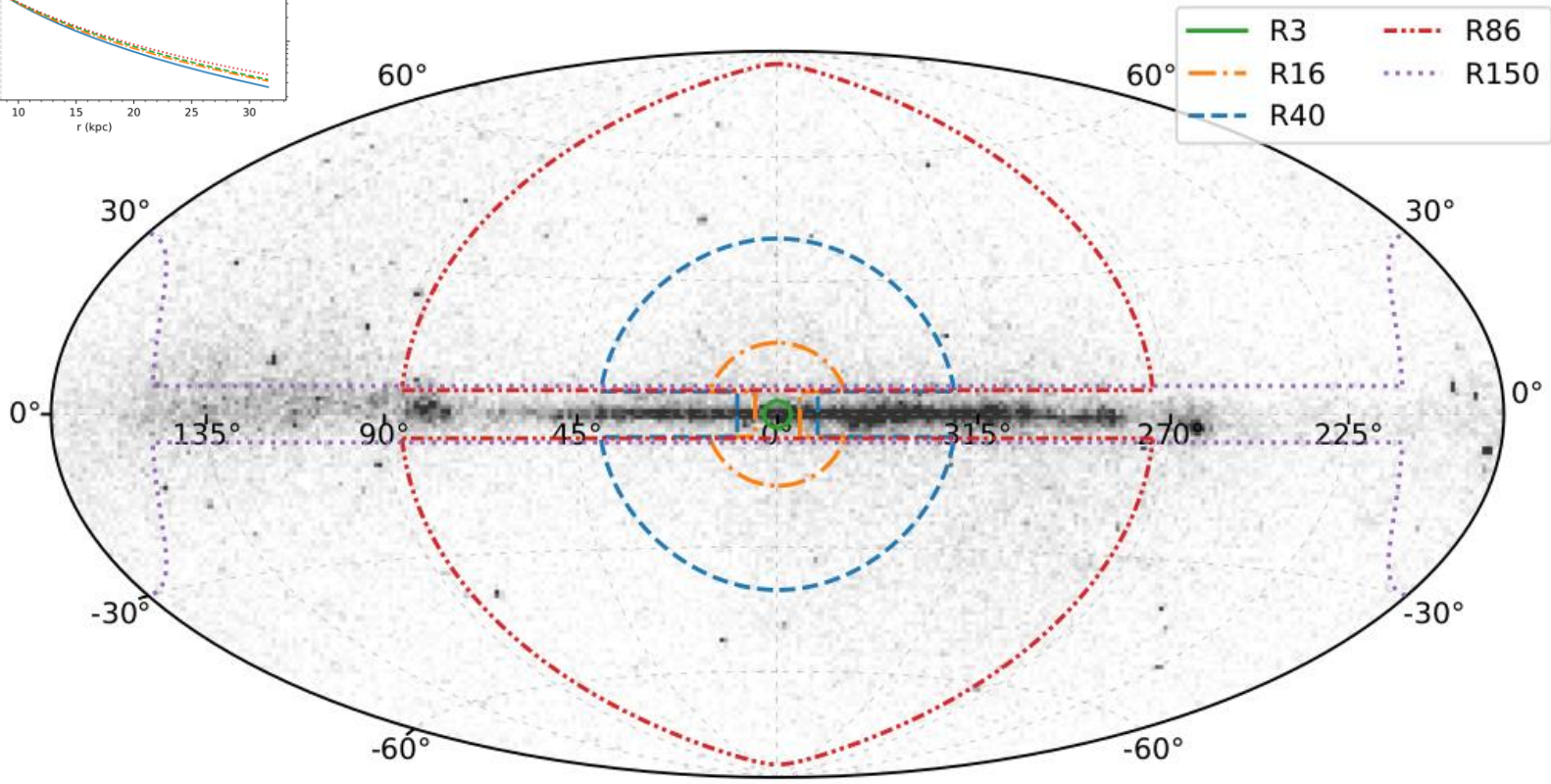




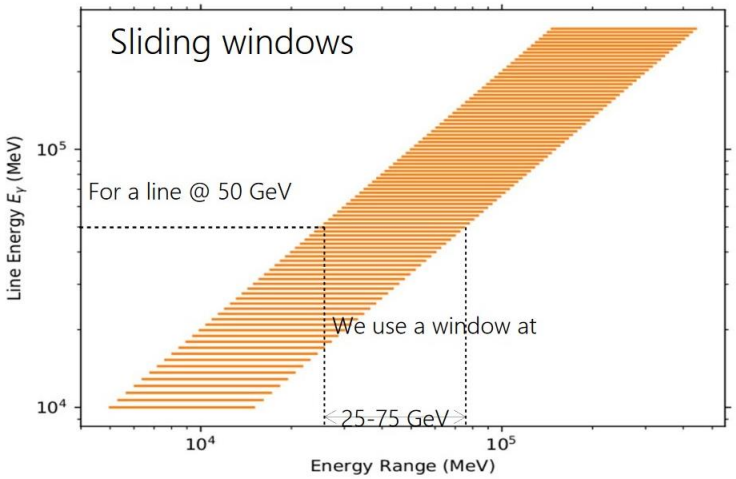


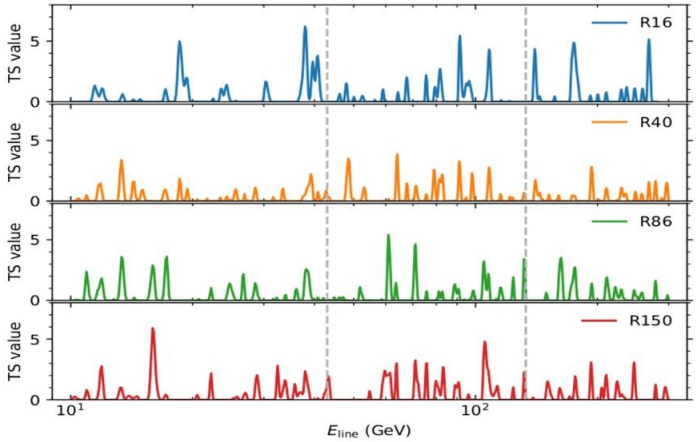
Line Search ROIs

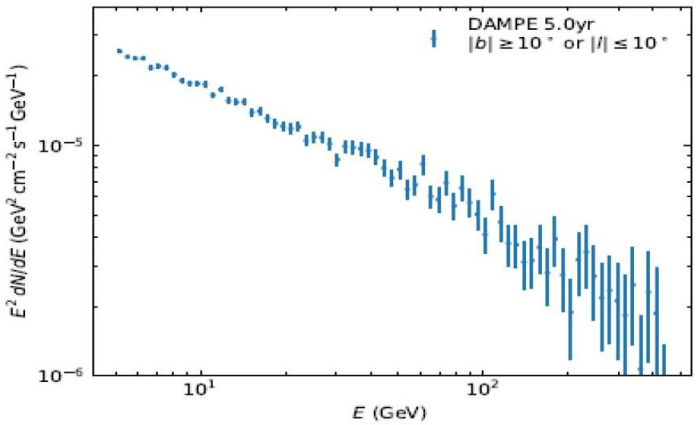




Line Search Method







Unbinned Likelihood:

$L(\Theta) = L_1(\Theta) \times L_2(\Theta)$,

where 1 and 2 represent the two data sets, and

$\ln L_k(\Theta) = \sum_{i=1}^{N_{\rm ph},k} \ln[\bar{\lambda}_k(E_i;\Theta)] - \int_{E_{\rm min}}^{E_{\rm max}} \bar{\lambda}_k(E;\Theta)\,{\rm d}E$

Null hypothesis:

$\bar{\lambda}_{{\rm null},k}(E;\Theta) = F_{\rm b}(E)\,\bar{\epsilon}_k(E)$

Alternative hypothesis:

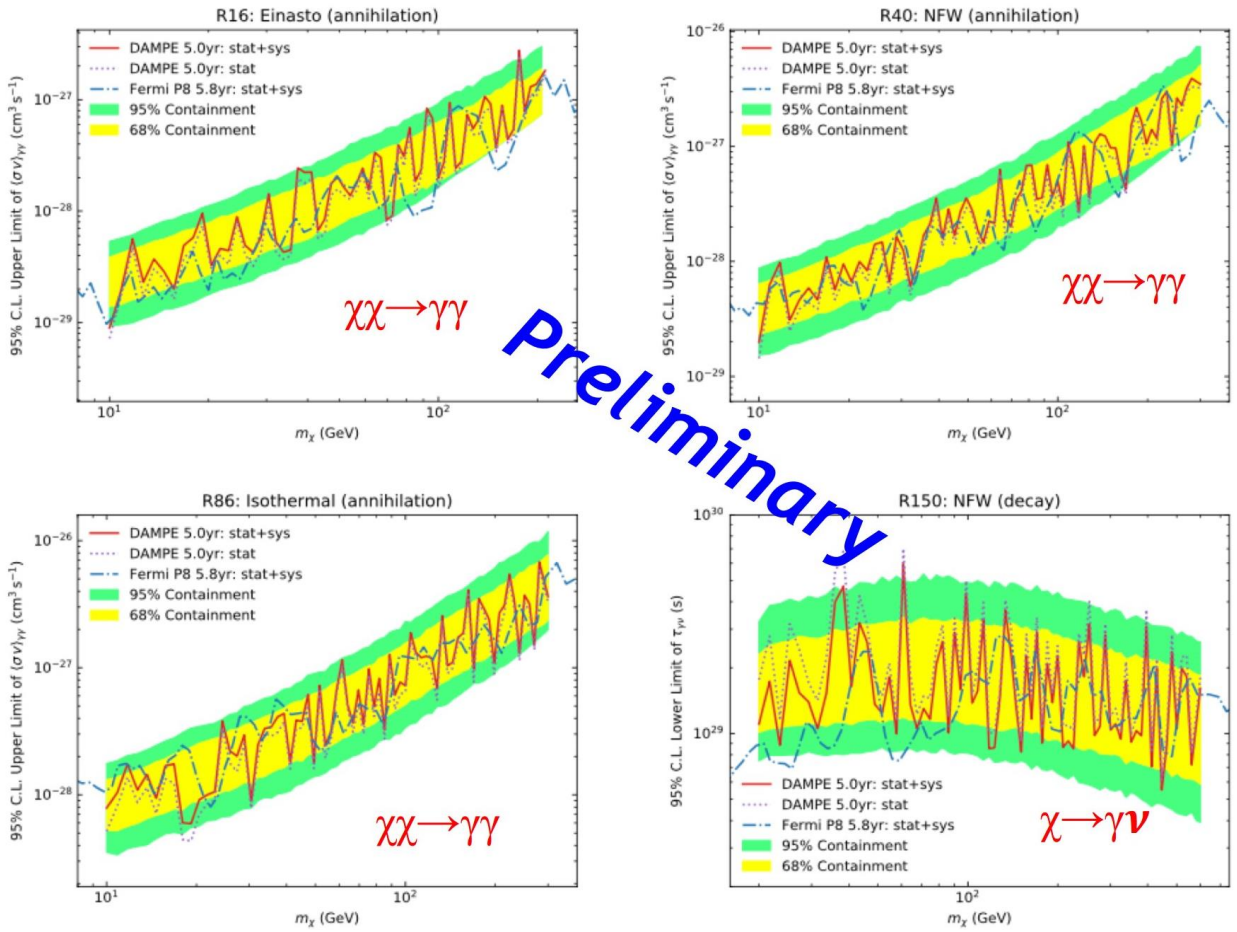
$\bar{\lambda}_{{\rm sig},k}(E;\Theta) = F_{\rm b}(E)\,\bar{\epsilon}_k(E) + \bar{F}_{{\rm s},k}(E)\,\bar{\epsilon}_k(E_{\rm line})$

where,

$F_{\rm b}(E;N_{\rm b},\Gamma) = N_{\rm b}\,E^{-\Gamma}$

$\bar{F}_{{\rm s},k}(E;N_{\rm s},E_{\rm line}) = N_{\rm s}\,\bar{D}_{{\rm eff},k}(E;E_{\rm line})$,

constraint on dark matter annihilation cross section or lifetime of decay



Summary

- After more than five years of operation in space, DAMPE has collected more than 0.22 million gamma-rays.
- We have detected 222 gamma ray bright sources and associated with 4FGL to determine the types of these sources.
- Fermi Bubbles has been detected by DAMPE with >18 σ, the spectrum of bubbles is consistent with Fermi-LAT.
- No line structure has been found with DAMPE, stronger constraint for annihilation cross section or lifetime of decay were derived from large ROI thanks to the excellent energy resolution of DAMPE.

Thanks for your attention!